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Constructional Project

EPE MOODLOOP

ANDY FLIND

Relax in your own personal "space". A NEW PIC design generating selectable Alpha, Beta, Delta and Theta fields.

PUBLISHED in July '99, the *EPE Mood PICker* and its predecessor the *EPE Mood Changer* (June '98) both proved to be extremely popular with constructors.

These devices generated weak magnetic fields at "brainwave" frequencies, which are thought to encourage mental states of relaxation, creative mental imaging and even sleep. In fact, much of the feedback received from constructors concerned the ability to induce sleep since it has frequently proved very helpful in cases of insomnia.

BRAINWAVES

To begin with some theory for readers not acquainted with this field, the human brain exhibits electrical activity in the form of tiny alternating currents. Using extremely sensitive equipment it is possible to monitor these currents from voltages present at the skin surface of the head and it has been established that different frequencies correspond to some extent with the subject's mood or mental state.

Of the frequencies established to date, the most important from our point of view fall into four broad categories which have been named by researchers. The lowest band is called *Delta* and covers the range from 0·5Hz to about 4Hz, and is found during deep sleep and in very young babies. The second is *Theta*, which spans 5Hz to 7Hz and is associated with creative mental imagery or mental picturing. Researchers have shown much interest in this area in recent years.

WARNING NOTICE

It is known that photic stimulation at Alpha frequencies can cause seizures in persons suffering from Epilepsy. We would therefore also suggest that it is not wise for such people to try this project.

A user who is not a known epileptic, but when using the *EPE Moodloop* begins to experience an odd smell, sound or other unexplained effects, should TURN IT OFF IMMEDIATELY and seek professional medical advice.

The next frequency band on the scale runs from 8Hz to about 12Hz and is known as *Alpha*. This is the range that first came to the attention of people outside the medical profession when it was observed in Zen practitioners during a session of deep meditation.

This led to the notion that learning to generate high levels of Alpha activity might allow access to these deep meditative states without the years of rigorous training normally required. Needless to say this proved less than strictly true but many experimenters would agree that it is at least a step in the right direction and meditators sometimes refer to the "Alpha" state, which usually implies deep relaxation.

The highest brainwave frequencies commonly found are between 18Hz and 30Hz, and are called *Beta* waves. They appear during the normal alert, wakeful state. Other brainwave frequencies exist but are not as well defined and are rarely encountered outside medical EEG research.

FORCE FIELD

Various ways of encouraging the brain to generate specific electrical frequencies exist, one of which is exposure to a suitable alternating magnetic field. Opinions on how this works vary but one likely method seems quite simple. An alternating magnetic field induces electrical currents in conductive material within range and brain tissue is such a conductor.

It seems likely that the production of weak currents of suitable frequency within the brain will either tend to produce the desired mental state directly, or it may do so by encouraging the brain to "synchronise"

to the frequency. Either way, the effect is one many people find worthwhile as shown by the interest in the two projects published so far in *EPE*.

Both of these produce tiny localised magnetic fields. This new project represents an attempt to increase the effect by delivering a much larger current into an inductive loop system which may be placed right around a small room (or around a bed in the case of insomnia!) to permeate a whole area with the desired field.

Roughly speaking, it can saturate an
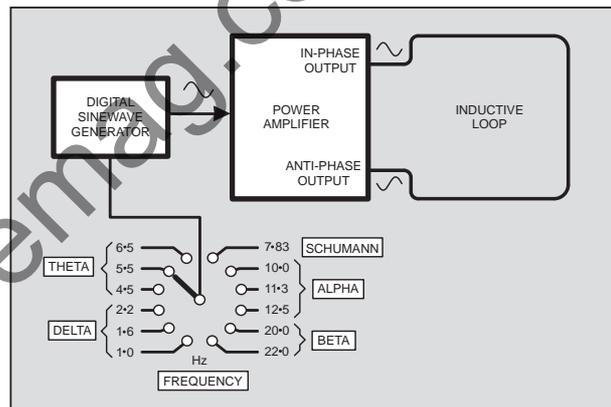
Fig.1. Block diagram for the EPE Moodloop.

area of up to four metres square with a field of intensity equal to that of one of the previous designs at a range of about three centimetres. This should be sufficient for the most ardent enthusiast of the system.

HOW IT WORKS

The circuit consists of a low-frequency sinewave generator followed by a power amplifier designed for optimum performance at frequencies right down to d.c., see Fig.1. Low-frequency sinewaves are most easily produced using digital synthesis techniques, for which the PIC16F84 microcontroller is well suited.

A bunch of resistors with suitable values are connected to the eight outputs of Port B of the PIC, which are turned on and off in sequence at suitable intervals to give the desired frequency. The resulting output waveform is "stepped", but adequately sinusoidal when viewed on an oscilloscope, certainly sufficiently so for this project.

Each cycle takes a total of sixteen steps and the outline of the program flow is shown in Fig.2. It operates as follows.

Switches connected to the lowest four bits of Port A are used to select the desired output frequency. During initialisation Port A is configured as all input (only the lower five bits are available anyway), Port B is set to all output and both are cleared.

Next, the state of port A is copied into a register called "PTR" (for "pointer" as it is used to select the timing delay for each step). Then the main output program commences its run.

It begins by checking the current state of the four bits of Port A against the value held in "PTR". If they differ the program returns to the start where the new value is read into the register. Otherwise the first bit of Port B is set high and the appropriate delay selected by means of a "tabled go-to" and executed.

This process is repeated a further sixteen times until all eight bits of Port B are high and the output is at the maximum value. The next eight steps then sequentially set them all low again and this process is repeated continuously to generate a steady sinewave output at the selected frequency.

Points to note by anyone examining the software are firstly that the input states are read using the command "COMF" instead of the more usual "MOVF" since they are "active low", as this command inverts them so they arrive the right way up. All the delays are composed of two nested loops which take a fixed number of clock cycles to execute and hence occupy a finite time.

As the whole program is time-dependent, it is liberally sprinkled with "NOP"s to improve accuracy. The calculated output frequencies are all within a tiny fraction of a percent of the intended ones and some are theoretically spot-on.

TIME CHANGE

The software differs in a number of ways from that of the *EPE Mood PICker*.

The timings are different since it uses a 4MHz crystal in place of the Mood PICker's 32kHz watch crystal, and the output frequencies have been changed slightly. Using a 4MHz crystal also means that the PIC is operated in XT mode instead of LP.

Different resistor values are used to generate the sinewave which no longer uses two steps at the top and bottom of each cycle, so these now execute in sixteen steps each instead of eighteen.

The outputs are turned on in sequence from 0 to 7, then turned off again from 7 to 0, rather than 0 to 7 as in the previous design. This makes little practical difference of course, but does provide a change for the programmer!

Details on obtaining the software are given in *Shoptalk*.

Fig.2. EPE Moodloop *software flow diagram.*

CIRCUIT DETAILS

The full circuit diagram for the *EPE Moodloop* is shown in Fig.3. The main supply was chosen to be about 12V so the first task is to reduce this to a suitable operating voltage for the PIC.

Normally this would be done by a regulator referenced to the negative (ground) supply rail, with a.c. coupling between the signal and the output amplifier. This proved unsatisfactory for this design because the very low frequencies necessitate large coupling capacitors and their charging times result in long settling times when the unit is switched on.

The solution employed was to split the supply voltage with resistors R1 to R3 to obtain two voltages with a difference of about 4V, symmetrically about half the supply, which are buffered by op.amps IC1a and IC1b to become positive and negative supplies for the PIC, IC2. These have their own local decoupling capacitors C4 and C5 whilst Zener diode D1 protects IC2 in the event of brief excursions beyond its safe supply range.

A further local decoupling capacitor C8 is provided in close proximity to IC2. The OP279 dual op.amp features rail-to-rail outputs capable of currents of up to 80mA, making it particularly suitable for this application.

A further advantage of supplying the signal generating part of the circuit in this manner is that since the output is directly proportional to the supply, the drive to the output amplifier varies in direct proportion to the main supply. This means that the circuit works with optimum drive level for supplies from below 9V up to about 15V with no further adjustment after the initial setting up. A conventional regulated supply would not offer this feature.

ACTIVE INPUTS

The four inputs RA0 to RA3 of IC2 have "pull-up" resistors R4 to R7 from the positive supply to IC2 so that the frequency selection switches are "active low", pulling them to negative when "on". A quad d.i.l. switch S1 to S4 is fitted to the p.c.b. for testing but a panel mounted rotary switch S5 may also be used, more concerning this later.

Resistors R9 to R16 convert the output sequence from IC2 to a sinewave, and the final level is trimmed to the optimum value with preset potentiometer VR1. This preset is arranged with supply splitting resistors R17 and R18 so that the output signal stays symmetrical about the midpoint of the main supply, allowing d.c. coupling to the output stages.

Capacitors C9 and C10 remove high frequency components of the "stepped" waveform to eliminate r.f. interference radiation, important in a circuit which is going to be connected to what, in effect, is a large aerial!

OUTPUT DRIVE

For maximum drive with the 12V supply a "bridge-tied" output is used, where the load is connected to two amplifier outputs (IC4a and IC4b), one of which is in-phase with the input whilst the other is anti-phase. This effectively doubles the output voltage to the load. An anti-phase signal is needed to drive the second amplifier so this is obtained using the op.amp inverter IC3.

Two identical output stages are used. They have to be capable of a maximum current of about 1A, with a mean of about 650mA. Op.amps capable of this level of output current are available but tend to be expensive so a design using power transistors to boost op.amp output power was decided upon instead.

The dual OP279 device was again chosen as the op.amp for its excellent output stage characteristics. Each amp drives the output directly through a 68 ohm resistor (R26, R31), but when the voltage across this resistor rises above about 0·6V in either direction the associated transistor will begin to conduct to provide the necessary load driving power.

The voltage gain of each output stage is about 5·5 so the total gain of the two stages in bridge mode is about 11. To prevent instability occurring with some types of load, resistor/capacitor "snubber" networks (R29/C14 and R32/C16), between each output and ground (0V) are used. Finally, capacitors C12 and C13 reduce the gain at high frequencies, also to improve stability and reduce high frequency components in the output.

Little mention of the frequency selection switch has been made so far. Although the unit can be operated with d.i.l. switches (one is provided on the p.c.b. for testing), it was decided to provide a rotary switch in preference to the fiddly binary d.i.l. switches.

A binary coded rotary switch can be used but most available types appear to be expensive, intended for p.c.b. mounting, fitted with non-standard shaft sizes or otherwise unsuitable for this project. So, a cheap 12-way rotary switch S5 was fitted with sixteen diodes D2 to D17 to provide a binary weighted output on four wires connected to pull-up resistors at the opposite end. The circuit arrangement for the switch and diodes is also shown in Fig.3 and their physical layout in Fig.5.
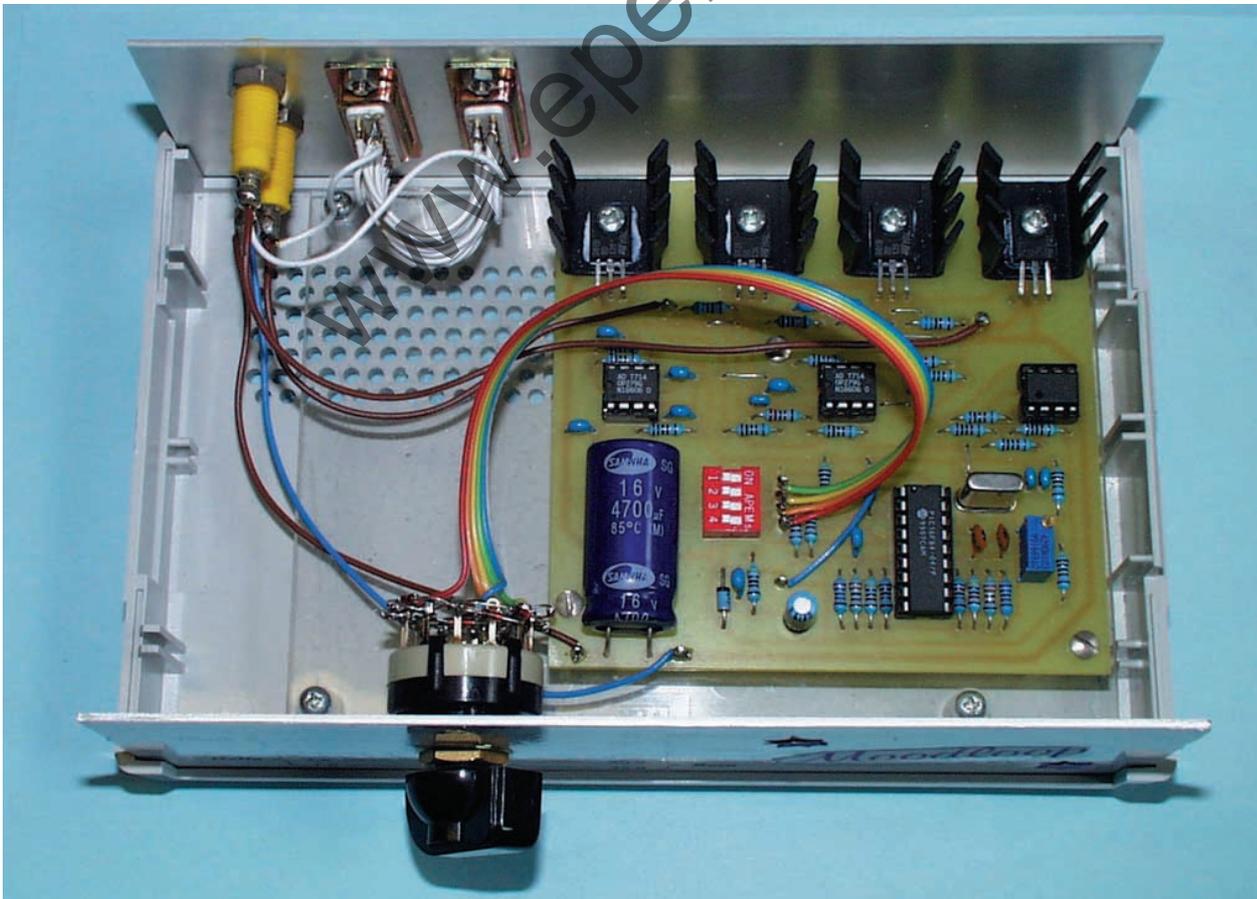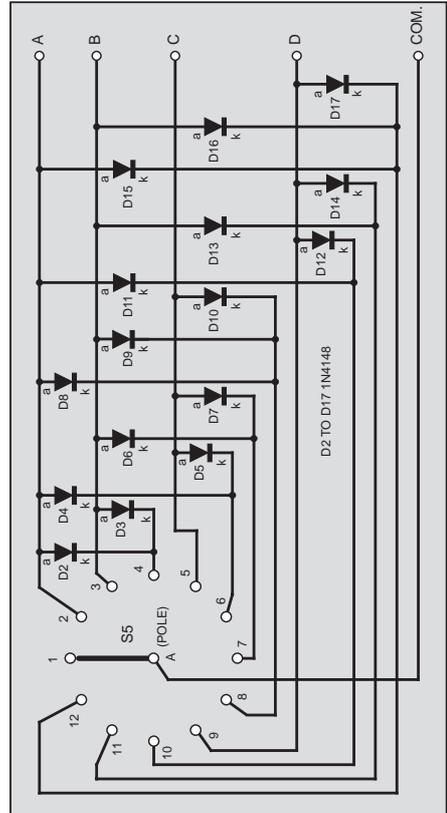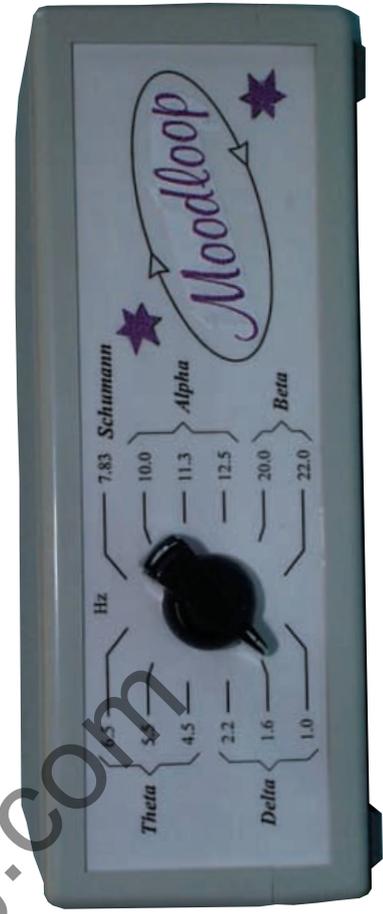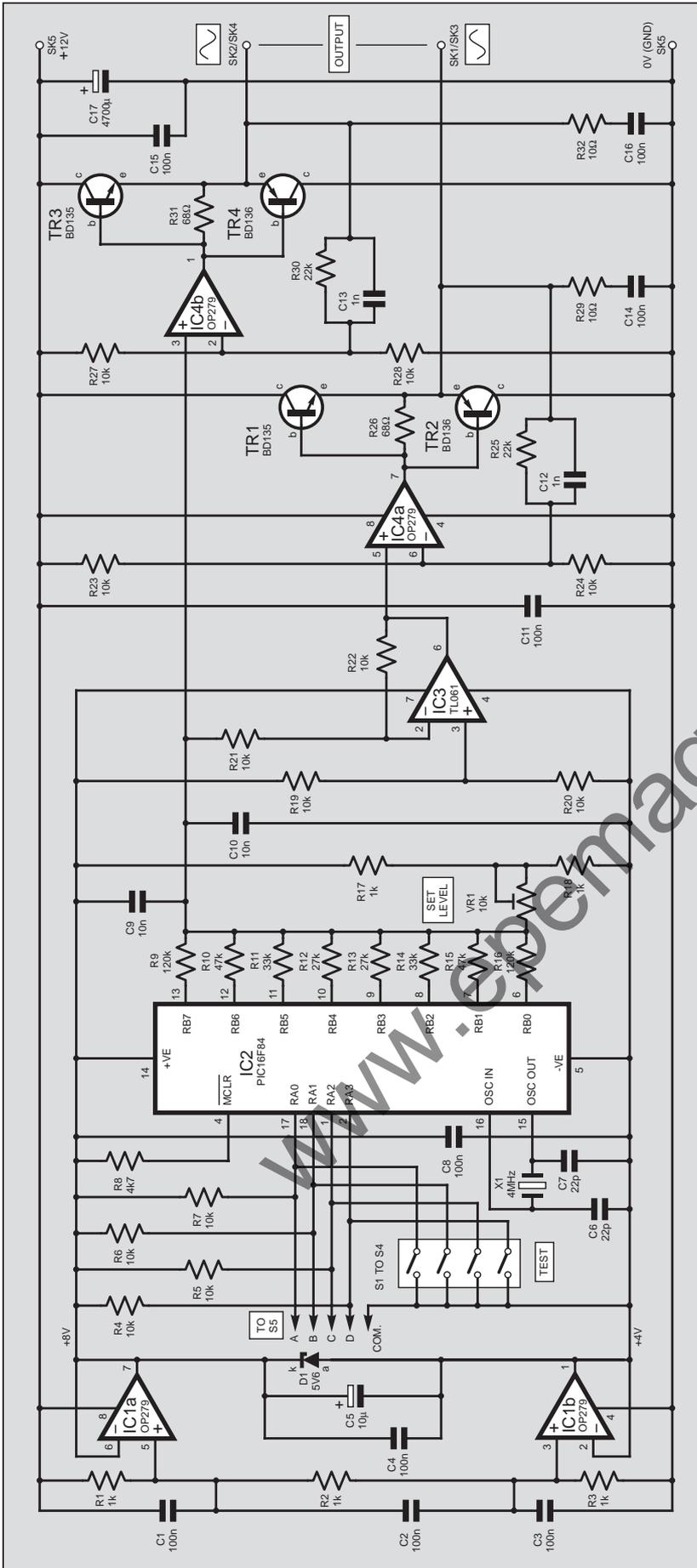
Fig.3. Complete circuit diagram, together with the frequency range switching, for the EPE Moodloop.

CONSTRUCTION

The *EPE Moodloop* is built up on a medium size single-sided printed circuit board (p.c.b.) and the component layout and full size copper foil master pattern are shown in Fig.4. This board is available from the *EPE PCB Service*, code 271.

Construction should not present too many problems. There are six links which should be inserted first, followed by the resistors and the small capacitors. D.I.L. sockets are recommended for the four i.c.s as these simplify testing.

The large electrolytic capacitor C17 should not be fitted until testing is complete as until the load is connected it takes a long time to discharge when the power is disconnected. If a current-limited bench supply is used for testing it can cause a slow voltage rise at switch-on which in turn can lead to the PIC failing to start up correctly.

The four output transistors are mounted on small heatsinks. In the prototype they do not have insulated mounting washers and were just screwed on using dabs of heat transfer compound. Since the transistor mounting tabs are not isolated, they and the heatsinks must not come into contact with each other or with any parts of the circuit and surrounding metalwork.
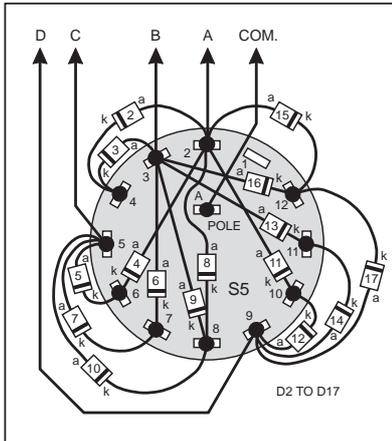
Fig.5. Frequency selection switch S5 construction and wiring.

TESTING

For testing, the completed circuit should first be powered with a supply of 12V without any i.c.s fitted, preferably from a current-limited bench power supply. Until the load is connected, it will draw only a small current. Without the i.c.s it should draw about 6mA. The aim of this test is to check for any drastic problems before putting any of the i.c.s at risk, so it is worth doing.

If all appears well, IC1 can be inserted, the circuit powered again and the PIC supply tested. This will be found across the leads of Zener diode D1 (positive on the cathode, negative at the anode) and with a 12V supply it should be about 4V. If this checks out IC2 can now be inserted, following which things become more interesting.

Although the final intention is to fit a 12-way rotary switch for frequency selection, for testing purposes an inexpensive 4-way d.i.l. switch S1 to S4 is provided on the board. Readers will be aware that this gives access to sixteen possible combinations, four more than the rotary switch. These have been programmed as special test frequencies.

The switches are binary weighted with S1 (top) as the lowest or least significant bit. A frquency of 0·5Hz is selected by the 13th setting, binary 12, given by S3 and S4 on, S1 and S2 off (8 + 4). Binary 13 (S1 + S3 + S4) gives 50Hz; 14 (S2,S3 and S4) sets all IC2 outputs high and 15 (all four on) sets all low.

With IC2 inserted the suggested testing procedure is as follows. The supply should be adjusted to exactly 12V for these checks. A voltmeter should be connected with the negative lead to the bottom (anode) lead of Zener diode D1 or the "common" connection point for switch S5, these being the negative supply for IC2, and pin 3 of the socket for IC4, which is the output resistor network from IC2.

With d.i.l. switches S1 to S4 all "on", preset VR1 should be adjusted for an
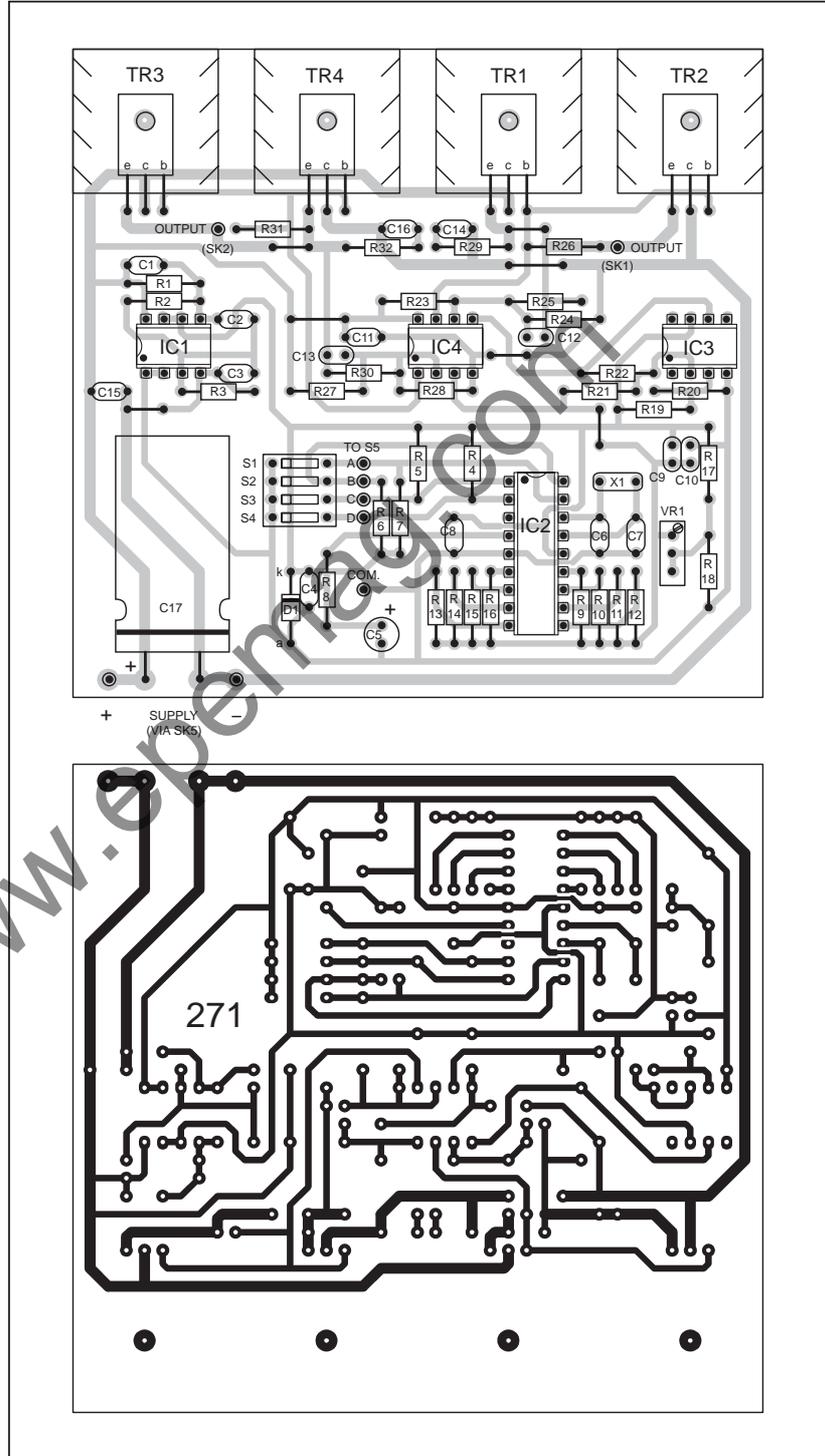
Fig.4. Printed circuit board component layout and full size underside copper foil master pattern.

indication of 1·0V. Switch S1 should then be set to "off", which should cause the reading to rise to about 3·0V.

IC3 should now be inserted on the p.c.b. This loads the output network slightly so it should reduce the above readings to about 1·2V and 2·8V. Their inverse should appear at the output of IC3, pin 6.

An analogue meter may now be used to check the action if the constructor prefers. With switches S3 and S4 "on", others "off", it can be observed following the 0·5Hz signal. With S2 "off" and the rest

FREQUENCY SWITCH

The Frequency Selector S5 switch will probably have an end-stop behind its mounting nut to limit the number of selectable positions so this should be adjusted to give all 12 positions. In the type used in the prototype it was necessary to remove this device altogether.

Although some care is needed to ensure the diode leads do not short together, the assembly is not as difficult as it looks. It is best to solder the diodes directly to the

Mount the frequency switch diodes directly on the switch tags before the switch is fitted in the case.
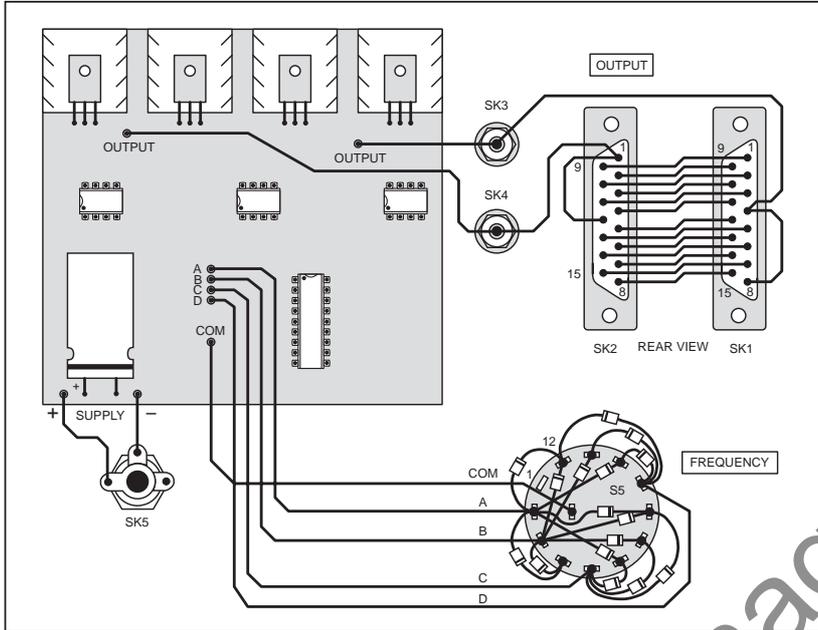
Fig.6. Interwiring from the p.c.b. to off-board components.

"on", the 50Hz output should give an average d.c. reading of about 2·0V. A digital voltmeter (DVM) on an A.C. range should read about 550mV r.m.s. for this output.

Next, IC4 can be fitted on the p.c.b. and a DVM connected across the output terminals, at SK3 and SK4. It should read about 6·0V r.m.s. on 50Hz, or ±8·6V d.c. for the "all high" and "all low" switch settings.

If these tests are all OK the large electrolytic C17 can be fitted. This is mounted horizontally as shown to reduce the overall height of the completed board. The prototype has a spot of "Blu-tack" to hold it securely but glue or double-sided adhesive foam would serve as well.

The p.c.b. should now be ready for use but if a suitable load is available, such as a resistor of about 8 ohms to 10 ohms with a rating of 5W or more, it can be tested at full power with this. It should draw about 600mA to 700mA and the resistor will warm up quite quickly. The r.m.s. reading for the 50Hz output should remain about the same, but it can be adjusted to an absolute maximum of 6·5V r.m.s. with preset VR1.

Note that the power supply used for making this adjustment should be capable of at least 1A, and that continuous operation into a load in the "all high" or "all low" test settings is not recommended as this puts the maximum output current continuously through just two of the output transistors which may cause overheating.

switch tags before mounting S5 in its case.

When switch S5 is connected to the p.c.b. the d.i.l. switches (S1 to S4) should *all* be "off" to enable it to operate correctly and, conversely, it should be at position 1, where all the outputs are open-circuit, if the d.i.l. switches are to be used for further testing. Out of interest though, if the d.i.l. switches are set up for binary 12 (S4, S3 on) the first four positions of the rotary switch will correspond to the four "test" settings, which may prove useful.

FINAL ASSEMBLY

The prototype model is fitted into a Vero "Patina" box with dimensions of 180mm × 120mm × 65mm, though a cheaper case can be used if preferred. The wiring between the p.c.b. and the switch, power and output sockets is shown in Fig.6. The prototype has no on-off switch as this is provided on the power supply, but one can easily be added if required.

The only points to note are that the metalwork of the transistors such as mounting bolts, heatsinks and so on **must not** come into contact with any other metalwork, and provision for airflow around the heatsinks must also be made. In the prototype this consisted of drilling plenty of holes in the top and bottom of the case, which can be seen in the photographs, and attaching stick-on rubber feet so that air can enter from below the case and leave by convection through the top. This has proved adequate in practice.
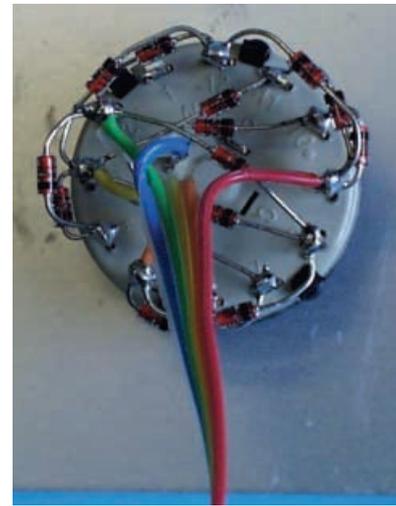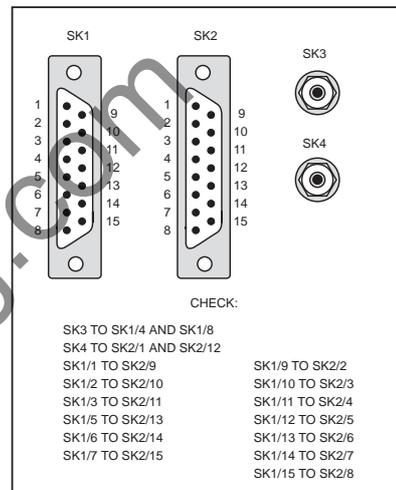
Fig.7. Output socket wiring check.

CHECK:

SK3 TO SK1/4 AND SK1/8
SK4 TO SK2/1 AND SK2/12

SK1/1 TO SK2/9	
SK1/2 TO SK2/10	
SK1/3 TO SK2/11	
SK1/5 TO SK2/13	SK1/9 TO SK2/2
SK1/6 TO SK2/14	SK1/10 TO SK2/3
SK1/7 TO SK2/15	SK1/11 TO SK2/4
	SK1/12 TO SK2/5
	SK1/13 TO SK2/6
	SK1/14 TO SK2/7
	SK1/15 TO SK2/8

INDUCTIVE LOOP

The output can be connected to just about any load with a resistance greater than 8 ohms, the ideal being around 10 ohms. It is intended to drive an "inductive loop" system consisting of multiple turns of wire running around the area to be subjected to the magnetic field.

One way to do this is to use ribbon cable with the cores connected end-to-end to form several turns in series. If the overall resistance is significantly higher than 10 ohms groups of series-connected turns can be connected in parallel to achieve the target resistance.

The prototype uses about 14 metres of ribbon cable connected to give one loop of 7 turns in parallel with another of 8 turns. Two 15-way D-type chassis sockets are fitted to the case and wired as shown in Fig.6 to achieve the necessary arrangement of the cable which is fitted with 15-way IDC D-type plugs.

Polarity of these is arranged so that pin 1 of one plug connects to pin 1 of the other, and so on. They allow loops to be installed and left in place, so that the *EPE Moodloop* unit can be taken to any desired location and just plugged in.
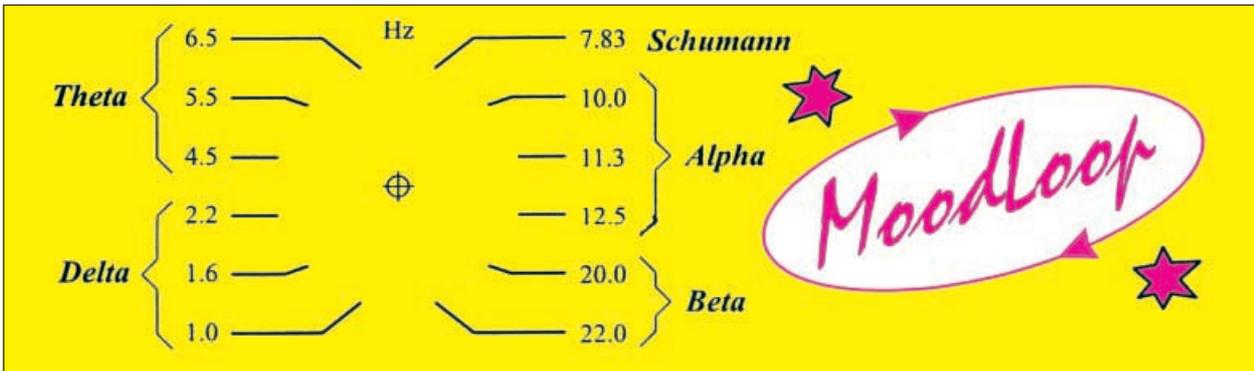
Full-size front panel legend master for the EPE Moodloop *project.*

For future experiments with other types of coil or loop the unit is also fitted with 4mm sockets (SK3, SK4). It would be quite simple to make a small adapter to connect these to multiway sockets of other types for different types of loop.

If the 15-way sockets are fitted and wired as shown, this should be done with extreme care as there will be little indication of errors. It is suggested that after wiring, continuity testing should be carried out from the front of the sockets as shown in Fig.7 to ensure that it is correct. The "loop" can then be plugged in and the overall resistance measured to ensure it has about the right value of 10 ohms.

COMFORT ZONE

Positioning of the loop is up to the user. The obvious position is around the area to be covered, at floor level or possibly higher, though if it were placed vertically, perhaps against a wall, anyone in front of or behind it would be exposed to the field. The suggested length of loop may allow more than one turn around a small area for even greater field strength!

It seems likely that the user's position relative to the field is not particularly important, so long as the strength is sufficient. Experiments with a sensitive magnetic field detector show that the field actually extends for quite a distance outside the loop.

It might also be interesting to try using a solenoid of suitable resistance, although this has not been attempted with the prototype yet. A point to watch here, though, is that a few watts of heat are dissipated by the load so it should have the ability to dissipate this, which may not be the case with a solenoid.

POWER SUPPLIES

Power for the unit is nominally 12V, but the prototype has been tested with supplies ranging from just below 9V to a maximum of 15V, at which setting the four heatsinks become rather warm, but not beyond acceptable limits.

The average current taken will normally be around 600mA to 700mA depending on supply voltage, but the peak current will be over 1A so the supply should be capable of this in view of the low frequencies involved. The voltage must be regulated, as fluctuations with load will cause corresponding distortion of the output so this rules out most "plug-top" supplies as most of these have no internal regulation.

Many constructors will already have suitable power supplies of some kind and

it is also possible to operate the unit directly from a car battery, where the use of "Alpha" frequencies may help to reduce "road rage", or "Beta" might combat fatigue on long trips. However, next month we will be giving details of a simple mains operated low-voltage regulated supply which can be used to supply this project and many others

SCHUMANN RESONANCE

Before ending, an explanation of the front panel setting labelled "7.83 Schumann" must be given. This refers to the "Schumann Resonance", an intriguing phenomenon amongst the naturally occurring magnetic fields that have always surrounded us. It appears that the space between the earth's surface and the ionosphere forms a gigantic resonant cavity having physical dimensions which give it a frequency somewhere between 7Hz and 8Hz. Events such as lightning exite oscillations in this cavity and very low attenuation at these frequencies allows them to keep going more or less continually.

Enthusiasts of the effects of fields at this frequency say that modern man is missing out on its supposed beneficial effects

because it tends to be masked by more powerful fields from the electrical equipment and wiring which nowadays surrounds us all. It has even been claimed that NASA installed Schumann frequency magnetic field generators in spacecraft after finding that space sickness was in part due to the astronauts travelling beyond the range of this field, although the author has been unable to confirm whether this is true.

However, constructors may now create the Schumann field in their own homes and judge for themselves whether it's effects are beneficial. ☐
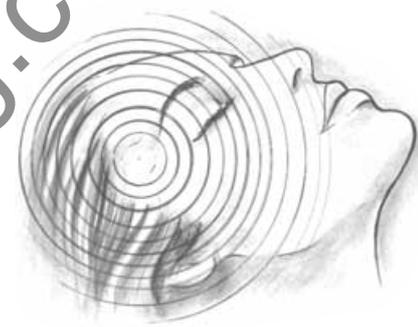
Completed EPE Moodloop *(right) together with* Moodloop Power Supply *(next month) and a* Field Strength Checker *(October issue).*